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Original Research

Does the angle and position of the syndesmosis screw in the axial plan affect the reduction of syndesmosis?

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Abstract
Aim: In this study, it was aimed to evaluate the reduction quality in surgically treated syndesmosis injuries and to determine the importance of the insertion position of the syndesmosis screw for the reduction quality.
Material and Methods: Sixty patients treated for syndesmotic injury were included in the study. To determine the reduction quality of the syndesmosis, both ankles were scanned with computed tomography. The distance between the medial fibula and the tibial incisura 1 cm above the joint level was measured at the most anterior (a) and the most posterior (b) edges. Rotation; The angle between the line tangent to the anterior and posterior tibial tubercles and the line passing through the anterior and posterior fibular tubercles was measured by (q1). The direction and position of the syndesmosis screw were evaluated according to the line tangent to the tibial tubercles (Vq).
Results: When the mean a, b distance and q1 angle were compared with normal ankle values, the difference between all values was found to be statistically significant ($p < 0.05$). A significant relationship was found when analyzing the relationship between screw position and reduction quality ($p = 0.008$).
Discussion: It has been found that placing the screw closer to the posterior provides better reduction compared to placing it closer to the anterior. A significant correlation was found between the screw insertion point on the fibula and the reduction of syndesmosis. No correlation was found between the angle of screw insertion in the axial plane and the malreduction of the syndesmotic joint.

Keywords
Ankle fracture, Syndesmosis, Malreduction, Malleolus

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Introduction

Ankle fractures are among the most common lower extremity injuries that often require surgical treatment. In order to minimize the risk of post-traumatic arthritis in displaced fractures, anatomical restoration of the joint surfaces should be provided [1]. In addition to treating the fracture itself, it is also important to achieve reduction of syndesmosis. In many studies, anatomical reduction of syndesmosis after ankle injuries has been associated with better clinical outcomes [2,3]. Syndesmotic injury has been the subject of many studies due to the difficulty in diagnosis, treatment type and surgical reduction. Diastasis resulting from the complete disruption of this complex structure can usually manifest itself on flat anterior-posterior ankle and mortise radiographs [4]. However, conventional radiographic measurements to evaluate the integrity of the tibiofibular relationship may yield inaccurate or inadequate results [5]. In recent studies, it has been advocated that computed tomography is the method of choice for evaluating syndesmosis reduction [6]. Many studies in the literature have reported the difficulty of obtaining an accurate reduction in syndesmosis after surgical fixation [7,8].

Although there are studies in the literature suggesting that misplacement of the syndesmosis screw causes anteroposterior translation of the fibula on the tibia incisura, there are not enough studies on clear reference points independent of anatomical variations for correct syndesmotic screw placement [9,10].

The aim of this study is to evaluate the reduction quality in operatively treated syndesmotic injuries and to determine the importance of screw insertion position on reduction quality, which is one of the intraoperative factors affecting syndesmosis reduction.

Material and Methods

Approval for this retrospective study was obtained from the ethics committee of our institution (No: 2020/214-3179). The records of patients who were operated on for ankle fracture accompanied by syndesmosis injury in our hospital between January 2019 and December 2019 were examined, and patients who met the inclusion criteria were determined. Inclusion criteria were (1) patients with ankle fracture, accompanied by syndesmosis injury and operated on, (2) those in the age range of 18-65, (3) having a follow-up period of at least 6 months and regular follow-up visits, (4) patients with postoperative computed tomography (CT) of both ankles. Exclusion criteria were (1) additional injury other than ankle fracture, accompanied by syndesmosis injury in the same extremity, (2) patients under followed up due to pre-operative chronic syndesmosis injury. Patients meeting these criteria were excluded. Among the 98 ankle fractures detected as a result of screening, 60 patients who were operated on who were found to meet the inclusion criteria were included in the study. Thirty-seven (61.7%) of these patients were male and 23 (38.3%) were female. The average age was 43.95 years (range; 18-64 years).

Surgical Technique

Fibula fixation consisted of fixation by using interfragmentary screw and a neutralization plate for spiral and oblique fracture patterns after anatomic reduction or as a bridge plating for partial fracture patterns. The Cotton test which is one of the intraoperative maneuvers, was used to detect syndesmotic damage during surgery, based on the principle of pulling the fibula laterally with a hook or clamp after internal fixation was applied to the fibula. The test was accepted as positive if there was a lateral movement of the fibula more than 2 mm [11]. Syndesmosis was reduced indirectly using a pointed reduction clamp with the ankle in the neutral dorsiflexion position. The clamp was placed approximately 1.5-2 cm proximal to the mortise level, just distal to the level where the fixation screw would be placed. Detection of decreased tibiofibular opening in fluoroscopic mortise image was interpreted as reduction. Syndesmotic fixation was achieved by sending a 3.5 mm transsindesmotic tricortical position screw parallel to the joint surface, aiming at an angle of approximately 30º from the posterolateral to the anteromedial of the tibia.

Radiological Evaluation

A CT scan of both ankles (Aquilion Lightning™, Canon Medical Systems) was performed on the postoperative 2nd day to evaluate the reduction quality of the syndesmosis, the position of the syndesmosis screw and to compare it with the normal healthy side. In order to clearly define syndesmosis, axial CT scans for both ankles were considered, allowing better visualization of the transverse relationship between the fibula and the incisura fibularis in the tibia. To avoid any discrepancy in axial scanning, the legs were standardized by placing them on the scanner at bilateral neutral adduction and 20 degrees of internal rotation. The thickness of the CT slices was planned as 2 mm. Evaluation of the CT scans was performed by an orthopedic and traumatology specialist. In order to obtain results consistent with the studies in the literature, the syndesmosis tibiotalar joint was evaluated in parallel axial scans, 1 cm proximal to the midpoint of the tibial plafond [5,12]. Two previously reported measurement methods were used to evaluate the syndesmotic reduction quality. In the first method, the amount of translation was evaluated comparatively by measuring the distance between the medial fibula 1 cm above the joint level and the incisura fibularis in the tibia at the front edge (a) and the rearmost edge (b) (Figure 1a). This method has been used in several studies with acceptable reliability [5,13]. As a result of the measurements, the difference between the anterior and posterior measurements for the operated and normal sides was calculated. A difference of more than 2 mm between these measurements was considered a poor reduction [5]. In the second method, it was aimed to measure the isolated rotation of the fibula with respect to the tibia. For this purpose, the angle (q1) between the line tangent to the anterior and posterior tibial tubercles and the line passing through the anterior-posterior fibular tubercles was measured (Figure 1b) [13,14]. The direction and position of the screw used to fix the syndesmosis were evaluated according to the line (Vq) tangent to the tibial tubercles (Figure 1c). The intersection point of the Vq with the syndesmosis screw was determined. Then the distance (Va) between this point and the anterior tubercle of the tibia and the distance (Vp) between the posterior tubercle of the tibia were measured and recorded. In the case of Va> Vp, the screw was considered to be anteriorly located, if Va <Vp, the screw was considered to be posterior. In addition, the angle (α)

between the syndesmosis screw and Vq was calculated and the statistical analysis of the relationship between the angle α and the anterior or posterior orientation of the existing screw was performed. However, a statistical analysis of the relationship between α angle and reduction quality was performed (Figure 1d). The correlations between the quality of syndesmosis reduction obtained as a result of the analyzes and dislocation, fracture type, screw joint distances and screw insertion angles were examined.

Statistical Evaluation

In this study, statistical data analysis was performed with IBM SPSS version 23. Basic statistics such as frequencies, percentages, averages, maximum and minimum values and confidence intervals of the appropriate variables were found. Correlation coefficients were calculated to determine the relationships between variables. The nonparametric Mann-Whitney Test was used to understand the mean order differences of two independent groups with non-normal dependent variables. The level of significance was set as $p < 0.05$ for all statistical analyzes.

Results

Thirty-six (60%) of the lateral malleolus fractures were type C, 24 (40%) were type B according to the Weber classification. When we look at the fracture types, 26 (43.3%) trimalleolar fractures, 19 (31.7%) isolated lateral malleolus, 10 (16.7%) bimalleolar fractures, 5 (8.3%) lateral and posterior malleolar fractures were evaluated. While 12 (20%) of the patients had dislocation together with ankle fracture, 48 (80%) patients had isolated ankle fractures. The distance of the syndesmosis screw to the insertion distance was 10 mm or less in 5 (8%) patients, between 11-20 mm in 33 patients (55%), and 21 mm and above in 22 patients (37%). When we look at the reduction quality, syndesmosis malreduction was detected in 24 (40%) of the total 60 cases in the postoperative CT scan (Figure 2). When the 24 cases with malreduction were evaluated separately, the distance 'a' in 11 (46%) patients, distance 'b' in 5 (21%) patients, and both 'a' and 'b' distance in 8 (33%) patients were more than 2 mm from the normal side (Table 1). The average value of the q1 angle on the operated side was 13.76 ± 6.39, while the average value on the normal side was 10.86 ± 0.23. When malreduction cases were examined separately, the mean value of the operated side q1 angle was 15.91 ± 6.1, and the mean value of the normal side q1 angle was 10.37 ± 1.88 (Table 1).

Mean values of a, b and a/b of the operated side were statistically significantly higher than the mean values of the normal side (Table 1). There was a significant difference between the mean q1 of the normal and operated sides ($p < 0.05$). The values of q1 on the operated side are significantly greater than on the normal side. When the malreduction cases were examined separately, it was found that the mean q1 angle of the operated side was statistically significantly higher than the mean q1 angle of the normal sides ($p < 0.05$). No statistically significant correlation was found in the Spearman correlation analysis of reduction quality with dislocation and fracture type ($p > 0.05$). When the relationship between reduction quality and screw joint distance was examined, in the analysis performed

Table 1. The mean and standard deviation of the analyzed series

	Operated side	Normal side	p value
[a] (anterior) (mm)	5,90±0,26	4.71±0.12	0.000
[b] (posterior) (mm)	7,93±0,19	7.09±0.11	0.000
[a/b] (anterior / posterior)	0,74±0,02	0.67±0.016	0.008
[q1] (°)	13,76±6,39	10.86±0.23	0.000

Table 2. Relationship of reduction quality with screw position and α angle

		REDUCTION QUALITY		TOTAL	p value
		GOOD	BAD		
SCREW POSITION	Anterior	4	10	14	0,008
	Posterior	32	14	46	
TOTAL		36	24	60	
α ANGLE	>90°	24	12	36	0,504
	<90°	12	12	24	
TOTAL		36	24	60	

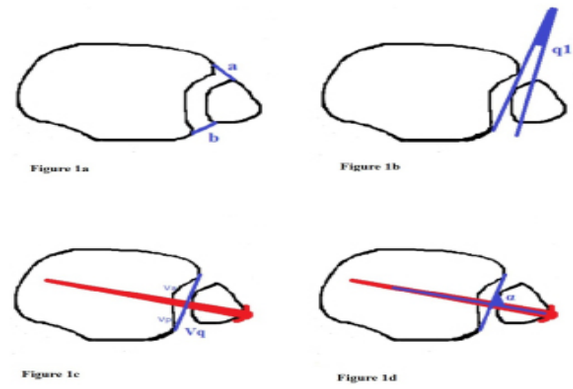

Figure 1. 1a-1d. Illustrations of the four methods used to measure the syndesmosis on an axial CT image. Figure 1a. This method measures the anterior incisura (a) and posterior incisura (b) distances. Figüre 1b. This method measures fibular rotation (R)

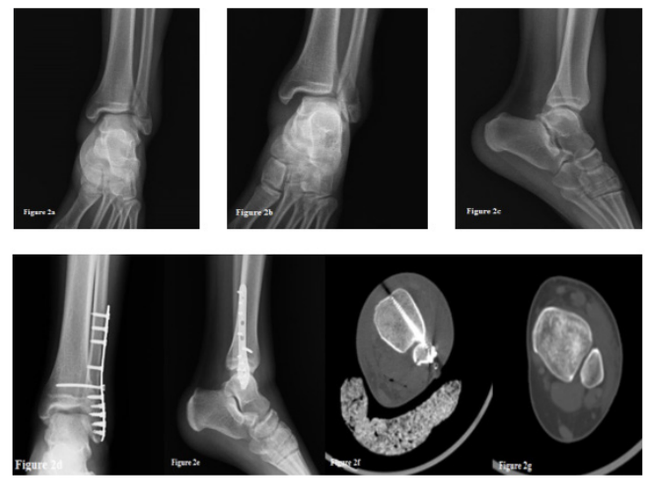

Figure 2. 2a-2f. A case example showing syndesmosis reduction in ankle fracture resulting from a supination external rotation injury. Figure 2a, 2b, and 2c Preoperative anteroposterior (Figure 2a), mortise (Figure 2b) and lateral (Figure 2c) radiographs

by dividing the screw joint distances of 10 mm and below, between 11-20 mm and over 21 mm on the operated side, no statistically significant relationship was found between the reduction quality and screw joint distance (p> 0.05). As shown in Table 2, in the analysis of the relationship between screw position and reduction quality, a significant relationship was found by calculating the p-value as 0.008 (p <0.05). In addition, no statistically significant correlation was found between the screw insertion angle less or more than 90 degrees and the reduction quality (p> 0.05).

Discussion

The results we obtained in this study are consistent with previous studies in the literature, according to which CT scans are a sensitive indicator that can be used to determine the quality of syndesmosis reduction [15-17]. In addition, a significant relationship was found between the postoperative syndesmosis malposition and the position of the screw in the anteroposterior axis in the axial plane in ankle fractures with syndesmosis injury.

Recently, new imaging and evaluation techniques that provide highly accurate information about syndesmosis damage and syndesmosis malreduction have raised interest in this topic [5,18]. Various methods have been proposed to measure the reduction quality of syndesmosis in axial CT scans, as well as different techniques to optimize operative syndesmotic reduction [12-14].

In studies in the literature investigating postoperative syndesmosis malreduction, its prevalence was reported to be between 16% and 52% [5,18]. In our study, the incidence of malreduction was found to be somewhat higher, although it had similar results with previously published studies. We attribute this high rate to the increased sensitivity of CT, which allows imaging of both rotational and sagittal translation of the fibula, and our use of the indirect syndesmosis reduction technique in all patients during surgery.

Previous clinical studies analyzing postoperative CT scans of syndesmotic screw fixation have suggested that misplacement of the syndesmotic screw in the axial plane causes anteroposterior translation of the fibula over the tibia incisura [9,10]. Lee et al. concluded that for optimal syndesmosis screw fixation, the screw should be parallel to the ground, while the tibial tubercle is perpendicular to the ground [19]. The findings in this study show that the angular relationship of the screw with the line passing through the tibial tubercles is not significantly related to the quality of the reduction, considering the axis that makes a 90° angle to the line that is tangent to the anterior and posterior tubercles.

One of the important issues in the treatment of syndesmosis injury is the restoration of fibular rotation. Thordarson et al. reported that rotational excess of more than 5° causes non-physiological loading in the ankle joint [20]. A prospective study by Vasarhelyi et al showed rotational asymmetry of more than 10° in 25% of cases [21]. In our study, the q1 value was measured to detect the presence of rotational asymmetry. According to the data we obtained, in the patients we included in the study, it was found that the average of the operated side was 2.9° higher than the average of the healthy side. When patients with malreduction were evaluated in isolation, this difference was determined as 5.5. We believe that the reason why the difference of 2.9° between the operated side and the healthy side averages in the patients we included in the study increased to 5.5° only in patients with malreduction is related to the location of the screw. In cases with malreduction, the increase in the frequency of anterior (Va) localization causes the fibula to roll in the incisura as a result of the compression of the screw placed in the anterior. This situation suggests that the q1 angle increases by causing internal rotation of the fibula. Some of the limitations of this study are the lack of clinical and long-term radiological follow-up. The strength of the study is that it has a sufficient number of cases to provide a “power factor”.

Conclusion

CT detects significantly more syndesmotic malreduction postoperatively than standard radiographic measurements. In addition, our results support that the most determining factor in the reduction of the fibula in syndesmosis damage is the correct reduction of the syndesmotic joint just before fixation during surgery, as well as the proper anteroposterior positioning of the screw used for fixation in the axial plane.

Scientific Responsibility Statement

The authors declare that they are responsible for the article’s scientific content including study design, data collection, analysis and interpretation, writing, some of the main line, or all of the preparation and scientific review of the contents and approval of the final version of the article.

Animal and human rights statement

All procedures performed in this study were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards. No animal or human studies were carried out by the authors for this article.

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Conflict of interest

None of the authors received any type of financial support that could be considered potential conflict of interest regarding the manuscript or its submission.

References

1. Miller AN, Barei DP, Iaquinto JM, Ledoux WR, Beingessner DM. Iatrogenic syndesmosis malreduction via clamp and screw placement. J Orthop Trauma. 2013;27(2):100-6.

2. Ebraheim NA, Elgafy H, Padanilam T. Syndesmotic disruption in low fibular fractures associated with deltoid ligament injury. Clin Orthop Relat Res. 2003;(409):260-7.

3. Mukhopadhyay S, Metcalfe A, Guha AR. Malreduction of syndesmosis are we considering
the anatomical variation? Injury. 2011;42(10):1073-6.

4. Andersen MR, Diep LM, Frihagen F, Castberg Hellund J, Madsen JE, Figved W. Importance of Syndesmotic Reduction on Clinical Outcome After Syndesmosis Injuries. J Orthop Trauma. 2019;33(8):397-403.

5. Gardner MJ, Demetrakopoulos D, Briggs SM. Malreduction of the tibiofibular syndesmosis in ankle fractures. Foot Ankle Int. 2006;27(10):788–92.

6. Elgafy H, Semaan HB, Blessinger B. Computed tomography of normal distal tibiofibular syndesmosis. Skeletal Radiol. 2010;39(6):559–64.

7. Porter DA. Evaluation and treatment of ankle syndesmosis injuries. Instr Course Lect. 2009;58:575–81.

8. Manjoo A, Sanders DW, Tieszer C. Functional and radiographic results of patients with syndesmotic screw fixation: implications for screw removal. J Orthop Trauma. 2010;24(1):2–6.

9. Van Heest TJ, Lafferty PM. Injuries to the ankle syndesmosis. J Bone Joint Surg Am. 2014;96(7):603-13.

10. Van den Bekerom MPJ, Hogervorst M, Bolhuis HW, Van Dijk CN. Operative aspects of the syndesmotic screw: Review of current concepts. Injury. 2008;39(4):491–8.

11. Jenkinson RA, Sanders DW, Macleod MD. Intraoperative diagnosis of syndesmosis injuries in external rotation ankle fractures. J Orthop Trauma. 2005;19(9):604–9.

12. Lepojärvi S, Pakarinen H, Savola O. Posterior translation of the fibula may indicate malreduction: CT study of normal variation in uninjured ankles. J Orthop

Trauma. 2014;28(4):205–9.
13. Dikos GD, Heisler J, Choplin RH, Weber TG. Normal tibiofibular relationships at the syndesmosis on axial CT imaging. J Orthop Trauma. 2012;26(7):433-8.
14. Nault ML, H´ebert-Davies J, Laflamme GY, Leduc S. CT scan assessment of the syndesmosis: a new reproducible method. J Orthop Trauma. 2013;27(11): 638-41.
15. Abdelaziz ME, Hagemeijer N, Guss D, El-Hawary A, El-Mowafi H, DiGiovanni CW. Evaluation of Syndesmosis Reduction on CT Scan. Foot & Ankle International. 2019;40(9):1087-93.
16. Muratli HH, Bicimoglu A, Celebi L. Magnetic resonance arthrographic evaluation of syndesmotic diastasis in ankle fractures. Arch. Orthop. Trauma Surg. 2005;125(4):222-7.
17. Carrozzo M, Vicenti G, Pesce V, Solarino G, Rifino F, Spinarelli A, et al. Beyond the pillars of the ankle: A prospective randomized CT analysis of syndesmosis' injuries in Weber B and C type fractures. Injury. 2018;49 (3):54-60.
18. Sagi HC, Shah AR, Sanders RW. The functional consequence of syndesmotic joint malreduction at a minimum 2-year follow-up. J Orthop Trauma. 2012;26(7):439–43.
19. Lee JY, Lim JH, Jung GH. Radiological indicator of reduction adequacy during ankle syndesmosis surgery: A computational cadaveric study. Injury. 2018;49(8):1491-6.
20. Thordarson DB, Motamed S, Hedman T, Ebramzadeh E, Bakshian S. The effect of fibular malreduction on contact pressures in an ankle fracture malunion model. J Bone Joint Surg Am. 1997;79(12):1809-15.
21. Vasarhelyi A, Lubitz J, Gierer P, Gradl G, Rösler K, Hopfenmüller W. Detection of fibular torsional deformities after surgery for ankle fractures with a novel CT method. Foot Ankle Int. 2006;27(12):1115-21.

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